06-SC-02, Project Engineering Design (PED)
Electron Beam Ion Source, Brookhaven National Laboratory, Upton, New York

1. Design Cost/Schedule History

	Fiscal Quarter				Total Estimated Cost (Design Only) ($000)
	A-E Work Initiated	Completed A-E Work	Physical Construction Start	Physical Construction Complete	
FY 2006 Budget Request (*A-E and technical design only*).....	1Q 2006	4Q 2007	N/A	N/A	3,500[a]

The project costs presented in the Project Data Sheet are preliminary estimates. The Performance Baseline is expected to be validated by the second quarter FY 2007. No construction funds will be used until the Performance Baseline has been validated.

2. Financial Schedule

(dollars in thousands)

Fiscal Year	Appropriations	Obligations	Costs
PED Only			
2006	2,000	2,000	2,000
2007	1,500	1,500	1,500

3. Project Description, Justification, and Scope

This PED request provides for Title I and Title II Architect-Engineering (A-E) services for the Electron Beam Ion Source (EBIS) project. The design effort will be sufficient to assure project feasibility, define the scope, provide detailed estimates of construction costs based on the approved design, working drawings and specifications, and provide construction schedules including procurements. The design effort will ensure that construction can physically start and long-lead procurement items can be procured in the fiscal year in which Title III construction activities are funded.

The flagship user facility at Brookhaven National Laboratory (BNL) is the Relativistic Heavy Ion Collider (RHIC), unique in the world for its ability to create an extremely high density state of nuclear matter called quark-gluon plasma. The operation of RHIC supports the scientific mission of the DOE by providing a world-class facility for Nuclear Physics Research. The quark-gluon plasma is created through the collision of heavy-ions accelerated to nearly the speed of light. This acceleration process is started at the RHIC pre-injector.

The present pre-injector for heavy-ions for RHIC uses the Tandem Van de Graaff, built around 1970. The beam is transported to the Booster via an 860 meter long line. The Electron Beam Ion Source

[a] The full Total Estimated Cost (design and construction) ranges between $12,000,000 and $17,500,000; and the full Total Project Cost (design and construction) ranges between $16,000,000 and $19,500,000. These estimates are based on preliminary data and should not be construed as a project baseline.

(EBIS) project will provide a new heavy-ion pre-injector for RHIC based on a high charge state heavy-ion source, a Radio Frequency Quadrupole (RFQ) accelerator, and a short Linear Accelerator (Linac), increasing the reliability and reducing the costs of RHIC operations. The highly successful research and development efforts of an EBIS prototype has led to advances in the state of the art in EBIS performance by more than an order of magnitude and now make it possible to meet RHIC performance requirements with a reliable, low maintenance, and cost-effective Linac-based pre-injector.

Linac-based pre-injectors are presently used at most accelerator and collider facilities with the exception of RHIC, where the required gold beam intensities could only be met with a Tandem until the recent EBIS research and development efforts. EBIS produces high charge state ions directly, eliminating the need for two stripping foils required with the Tandem. Unstable stripping efficiency of these foils is a significant source of luminosity degradation in RHIC. The high reliability and flexibility of the new Linac-based pre-injector will lead to increased integrated luminosity at RHIC and is an essential component for the long-term success of the RHIC facility. This new pre-injector based on an EBIS also has the potential for significant future intensity increases and it could produce heavy-ion beams of all species including uranium and polarized Helium - 3 beams. These capabilities will be critical to the proposed future luminosity upgrades and electron-ion collisions in RHIC.

The new RFQ and Linac are used to accelerate beams from EBIS to an energy sufficient for Booster injection. Injection into the Booster will be at the same location as is used for beams from the Tandem. The new pre-injector will be installed in the lower equipment bay of the existing 200 MeV Linac Building. Modifications to this building will be required to provide an injection path into the Booster and house the new equipment.

In summary, the proposed new pre-injector offers the following advantages:

- The EBIS replaces the ~33 year old Tandems with a modern, linac-based pre-injector.
- The RFQ and linac are simpler, modern, more robust technology, which will require less maintenance.
- The 860 m long Tandem-to-Booster transport line will be replaced with a 30-40m transport section.
- EBIS eliminates the limitations on ion species. While injection from the Tandems must start with negative ions, the EBIS can produce any ion species.
- The single EBIS would allow pulse-to-pulse switching between any two species. This leads to increased flexibility to handle the multiple simultaneous needs of RHIC, NASA, and the Alternate Gradient Synchrotron (AGS). Two tandems are needed for fast beam switching, while the new pre-injector will be able to switch species on a pulse-to-pulse basis.
- No stripping foils are required before the booster, so there will be better beam stability.
- The addition of the EBIS pre-injector has the potential to reduce operations costs through reduction of overhead hours and FTE support. The Tandem facility requires a staff of ~12 FTEs to support maintenance and a 24 hour shift rotation during operations. The linac-based pre-injector should be able to run unattended at most times, as with the present proton linac, and will require only a small staff of ~3 FTE's.

If the new linac-based pre-injector is not built, upgrades to the Tandems will be required in order to ensure reliable long term operation for RHIC. Construction began for the Tandem Van de Graaff facility in 1966, and it was commissioned in 1970. Many of the Tandem systems are still 1960's

technology, and those systems need to be modernized. Obsolete equipment would need to be replaced, and a computer-based control system installed. In addition, sufficient spares for some key components, such as accelerator tubes, would need to be purchased. The estimated fully-burdened cost of these required upgrades is ~$9,000,000.

4. Details of Cost Estimate

	(dollars in thousands)	
	Current Estimate	Previous Estimate
Design Phase		
Preliminary and Final Design costs (Design Drawings and Specifications at $2,340,000)	3,020	N/A
Project Management costs (5.7% of TEC)	200	N/A
Total, Design Costs (92.0% of TEC)	3,220	N/A
Contingencies		
Design Phase (8.0% of TEC)	280	N/A
Total Line Item Cost	3,500	N/A
Total, Line Item Costs (TEC)	3,500	N/A

Cost Estimates are based on pre-conceptual design effort.

5. Method of Performance

Design and inspection of the facilities and equipment will be by the operating contractor. Technical construction will be competitively bid, lump sum contracts. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive best value bidding process.

6. Schedule of Project Funding

	Prior Years	FY 2004	FY 2005	FY 2006	Outyears	Total
Facility Cost						
PED	0	0	0	2,000	1,500	3,500
Other Project Costs						
Conceptual Design	0	200	0	0	0	200
Total, Project Cost (TPC)	0	200	0	2,000	1,500	3,700

7. Related Annual Funding Requirements

There are no incremental costs to the RHIC Operations budget.